Hyperglycemia During Intravenous Fluid Therapy

A Clue to the Presence of Diabetes Mellitus

SAVELLY B. CHIRMAN, M.D., *Santa Barbara*

■ *Twenty-two patients receiving 5 per cent glucose solution intravenously during an acute illness were studied for evidence of hyperglycemia. Those in whom blood sugar rose above 100 mg per 100 ml (Folin-Wu) during intravenous therapy subsequently had impairment of carbohydrate tolerance as measured by oral glucose tolerance tests. The data collected suggested that blood sugar of 100 mg per 100 ml (Folin-Wu) or more developing in such a setting is a clue to the presence of diabetes mellitus.*

THE DEVELOPMENT OF hyperglycemia in patients receiving glucose-containing solutions intravenously during treatment of an acute illness is not uncommon. This finding is often casually dismissed by physicians as reflecting nothing more than the fact that the patient is receiving a large load of sugar and his system temporarily "saturated." Hyperglycemia in such circumstances is rarely regarded as an indication that diabetes mellitus may be present.

In contrast with this belief, recent work has shown that metabolically normal persons can tolerate large loads of intravenously administered glucose without deviation of the blood sugar to above-normal levels. Seltzer and Harris[1] gave 3,000 ml to 4,000 ml of 15 per cent glucose solution daily for five to seven days to normal persons and obtained mean blood sugar below 100 mg per 100 ml during the entire experiment in spite of a concurrent additional oral load of 220 to 300 gm of carbohydrate per day. This tolerance of continued and severe hyperglycemic stress differentiated the normal persons from tolbutamide-sensitive diabetic or insulin-dependent diabetic persons, in whom hyperglycemia and glycosuria did develop under similar glucose intake (see Chart 1.).

This data strongly supports the concept that the hyperglycemia which develops under intravenous glucose loading is an abnormality of a magnitude proportional to the basic physiologic impairment. However, the clinical value of Seltzer and Harris' study to the physician at the bedside is limited by the fact that 15 per cent glucose solutions are rarely, if ever, used to treat patients. Also, in the usual clinical situation the oral intake of patients who are being treated parenterally is usually quite restricted. Furthermore, acutely ill patients are under severe metabolic stress with increased adrenocortical activity which tends to promote the development of hyperglycemia, in contrast to the stable situation described in the Seltzer and Harris experiment. These facts suggested the desirability of determining whether hyperglycemia noted during treatment with the usual intravenous glucose-containing solutions in

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Reprint requests to: Department of Medical Education, Santa Barbara County General-Cottage Hospitals, P. O. Box 689, Santa Barbara 93105.

a clinical setting has a similar value as a clue to the presence of diabetes.

Materials and Methods

Acutely ill patients admitted to the Medical Service of the hospital were selected for inclusion in the study on the basis of the following criteria: (1) Presence of a disease requiring at least three days of intravenous fluid therapy which included 2,500 to 3,000 ml of 5 per cent glucose per 24 hours. (2) Absence of acute pancreatitis, wasting disease, malnutrition or known diabetes mellitus. (3) Absence of endocrinopathy or treatment with corticosteroids. (4) No recent or on-going treatment with thiazide diuretics. (5) Expectation of survival.

No attempt was made to alter the course of treatment undertaken by the house staff and attending physicians.

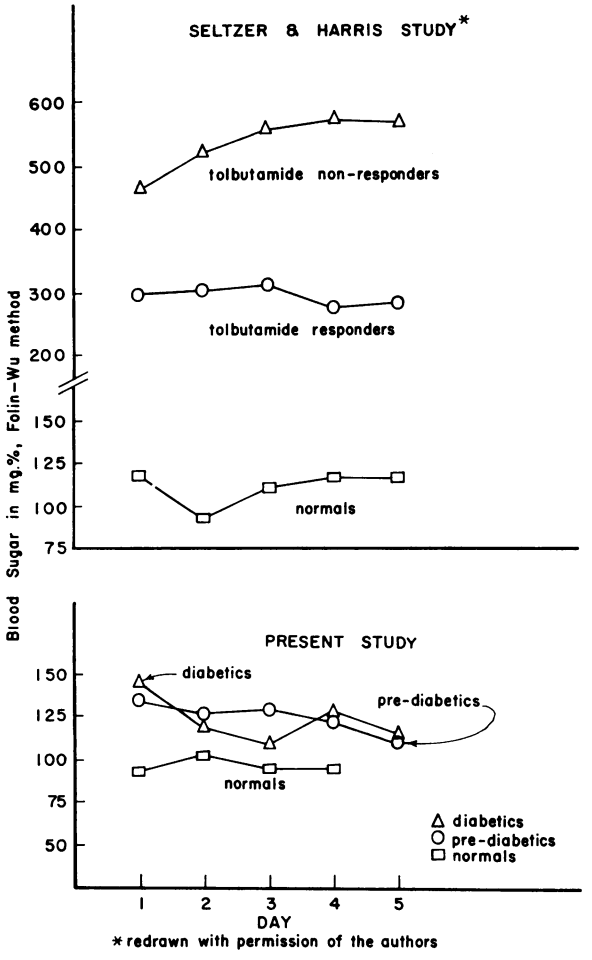

Chart 1.—Mean daily blood sugar values during intravenous glucose infusion: comparison of Seltzer and Harris experiment with present study.

Blood sugar levels were determined (Folin-Wu method) twice daily, at 8:00 a.m. and 3:00 p.m.: The specimens were obtained from a vein in an extremity not being used for infusion and were drawn while the patient was receiving parenteral fluids. In our laboratory this method yields results which average about 20 mg per 100 ml above those obtained with the Somogyi-Nelson (true glucose) method. All fluid intake and output was carefully recorded.

During convalescence, and at least two weeks after the acute phase of illness, each patient was given a diet providing 250 gm of carbohydrate per day, and a standard three-hour glucose tolerance test (SGTT) was performed three days later. Certain patients who had elevation of blood sugar during intravenous therapy or who had borderline standard glucose tolerance were further evaluated by the performance of a cortisone-glucose tolerance test.

Results

Forty patients were studied in a period of eight months. Clinical data about 22 are listed in Table 1. The others were dropped from the study because of death, insufficient fluid administration or inadequate data.

Despite the interest and cooperation of nursing staff and house officers, not all blood sugar determinations ordered were obtained: occasionally infusions were interrupted by blood transfusions, or had been stopped at the time blood specimens were to be drawn.

To evaluate results, the values given by Conn and Fajans for the standard glucose tolerance curve were increased by 20 mg per 100 ml and the curves interpreted by the values given in Table 2.

Except for patient 7, all patients in the normal group had blood sugar consistently below 120 mg per 100 ml and their overall mean blood sugar for all five days remained below 100 mg per cent. This compares with levels as high as 260 mg per 100 ml in those who later were found to have clearly diabetic glucose tolerance curves, and whose overall mean blood sugar was 122 mg per 100 ml for the five days of study. It was also interesting that patients whose standard glucose tolerance test was only suggestive of pre-diabetic state had an overall mean blood sugar slightly higher than the clearly diabetic patients. However, the difference is probably not statistically significant. These patients are classified as probable pre-dia-

TABLE 1.—*Venous Blood Sugar (mg per 100 ml, Folin-Wu Method)*

Patient	Sex	Age	Diagnosis	Number of Determinations 1	2	3	4	5
Non-Diabetic Patients								
1	F	77	Congestive failure	....	114	....	....	....
2	M	45	Esophagitis	....	....	116	....	....
3	F	47	Obesity	108	87	84	110	100
4	M	24	Chronic myelogenous leukemia	....	90	69	80	....
				....	....	68	....	....
5	M	49	Chronic lymph. leukemia	89	74	....	....	....
6	M	89	Senile dementia	89	106	115	....	....
				97	115	109	....	....
7	M	17	Peptic ulcer	....	131	105	....	....
				....	100	97	92	....
			MEAN	94	102	94	94	....
			SD	11	25	19	15	....
			Overall Mean = 96 mg per ml (4 days only)					
Diabetic Patients								
8	M	82	Bronchopneumonia	254	....	260	....	....
9	M	50	Stroke	105	....	....	169	....
10	M	85	Pyloric obstruction	130	114	....	130	....
11	M	49	Peptic ulcer	....	126	156	156	104
				....	....	....	....	104
12	M	37	Peptic ulcer	155	122	97	122	....
				110	105	100	110	....
13	M	34	Mitral stenosis	....	122	85	97	....
14	M	70	Emphysema	....	110	100	102	....
15	M	65	Stroke	122	102	....	....	....
				110	120	126	164	138
16	F	26	Scarlet fever	156	142	131	164	....
				....	....	100	92	....
17	F	80	Angina, ileus	....	124	....	100	....
				....	132	118	97	....
			MEAN	142	120	112	125	115
			SD	49	11.5	57	30	18
			Overall Mean = 122 mg per ml					
Pre-Diabetic Patients								
18	M	61	Cirrhosis, Rheumatoid arthritis	147	110	184	143	....
				....	....	136	110	....
19	F	17	Trauma	....	165	140	160	....
20	M	59	Adynamic ileus	126	88	100	122	....
21	M	64	Bronchopneumonia	....	114	....	122	94
				....	....	....	87	....
22	F	62	Hiatus hernia	....	156	92	102	114
				....	....	....	....	126
				....	....	....	....	116
			MEAN	136	126	130	121	112
			SD	15	32	37	25	14
			Overall Mean = 125 mg per 100 ml					

TABLE 2.—*Criteria for Interpretation of Glucose Tolerance Test (Venous Blood, Folin-Wu Method, in mg per 100 ml)*

Time	Normal	Diabetic	Probable Diabetic
Fasting	Less than 120	.....	.....
Post Prandial			
½ hour	Less than 180	.....	.....
1 hour	Less than 180	More than 180	More than 180
2 hours	Less than 130	More than 140	130 - 140

betics on the basis of subsequent grossly abnormal cortisone-glucose tolerance tests.

Statistical analysis of the data does suggest, however, that the values obtained for the three groups of patients that were classified as normal, diabetic and pre-diabetic on the basis of the SGTT or CRTT, probably represent samples from three distinct populations. Analysis of variance for a single measurement variable was applied. A 99 per cent level of significance was chosen to test the hypothesis that the data do not represent samples from three statistically different populations. Although the samples evaluated are small, and therefore the variances, as estimated by the standard deviations obtained, are not clearly homogenous, the results of the analysis are changed very little by assuming normal distribution and equal variance.[4]

On the basis of results of statistical analysis, the hypothesis was rejected.

Comments

These findings suggest that a metabolically normal person receiving the usual therapeutic quantities of glucose-containing parenteral fluids will remain euglycemic, even under the stress of severe illness and the added handicap of age. This means a true blood sugar level of about 80 mg per 100 ml, a conclusion consistent with the findings of Seltzer and Harris. It appears reasonable, therefore, to suggest that a patient with a blood sugar (Folin-Wu) of 100 mg per 100 ml or above under the circumstances described is likely to be diabetic and deserves a glucose tolerance test to rule out the presence of diabetes mellitus. A patient whose SGTT is borderline should undergo further study by way of a CGTT.

REFERENCES

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